NEC

User's Manual

Low-Voltage Starter Kit For Motor Control

Document No. U18220EE1V0UM00
Date Published June 2006

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Printed in Germany

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NOTES FOR CMOS DEVICES

① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ PRECAUTION AGAINST ESD

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ STATUS BEFORE INITIALIZATION

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

⑤ POWER ON/OFF SEQUENCE

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current.

The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

⑥ INPUT OF SIGNAL DURING POWER OFF STATE

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements.

Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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[MEMO]

Preface

Readers

This manual is intended for users who want to understand the functions of the low voltage starter kit for motor control.

Purpose

This manual presents the hardware manual of the low voltage starter kit for motor control.

Organization

This system specification describes the following sections:

- Kit Contents
- Hardware Setup
- Standalone Operation
- Drive and Motor Protection
- Software Setup
- Software Installation
- Using the NEC Electronics C Compiler and Source Code Debugger
- Download and Debug the Code
- GUI Operation

Legend Symbols and notation are used as follows:

Weight in data notation	:	Left is high-order column, right is low order column
Active low notation	:	$\overline{xxx}$ (pin or signal name is over-scored) or /xxx (slash before signal name)
Memory map address:	:	High order at high stage and low order at low stage
Note	:	Explanation of (Note) in the text
Caution	:	Item deserving extra attention
Remark	:	Supplementary explanation to the text
Numeric notation	:	Binary... xxxx or xxxB Decimal... xxxx Hexadecimal... xxxxH or 0x xxxx

Prefixes representing powers of 2 (address space, memory capacity)

K (kilo): $2^{10} = 1024$

M (mega): $2^{20} = 1024^2 = 1,048,576$

G (giga): $2^{30} = 1024^3 = 1,073,741,824$

[MEMO]

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Chapter 1 Introduction

The low-voltage starter kit for motor control (MC-LVKIT-714) is a complete 3-phase motor control evaluation system for NEC Electronics' microcontroller-type, application-specific standard products (ASSPs) for motor control.

The kit contains all necessary hardware and software to quickly set up and run a low-voltage brushless DC motor (BLDCM).

Figure 1-1: Motor Control Starter Kit

Chapter 2 Kit Contents

- MC-78F0714 micro-board containing the µPD78F0714 microcontroller
- MC-I/O board that interfaces between the micro-board and the power module
- Low-voltage power module (MC-PWR-LV) containing the power MOSFETs
- Pittman N2311 12V BLDC motor
- FW7362/15 DC power supply
- Sample software for a BLDC-Hall-714-LV 120-degree trapezoidal drive

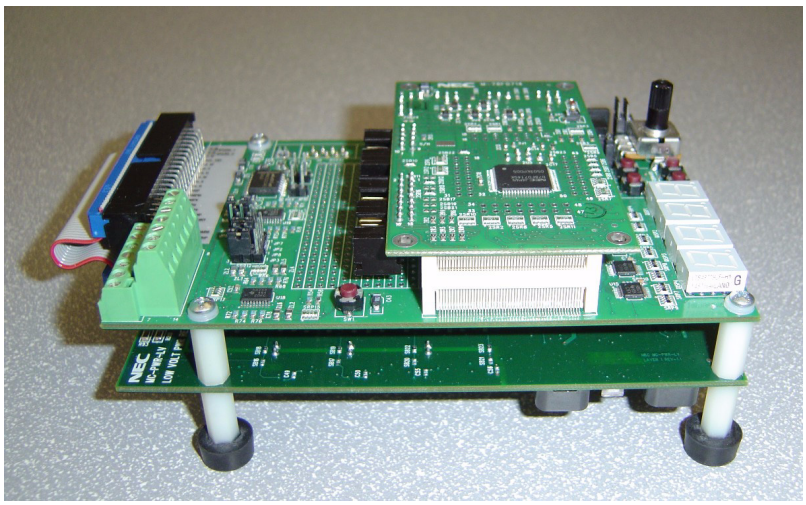
For information about the electrical characteristics and hardware functions of the µPD78F0714 microcontroller, refer to µPD78F0714 Preliminary User's Manual (U16928E).

For the instruction descriptions, refer to the 78K/0 Series Instruction User's Manual (U12326E).

Chapter 3 Hardware Setup

The kit can be purchased as one unit with all three boards connected as shown below:

Figure 3-1: MC-LV-KIT-714 Boards Stacked Up



To attach the motor, connect the phase U, V and W terminals to the J3 connector block on the MC-PWR-LV power board and the Hall sensor terminals to the J5 connector block on the MC-IO control board.

Table 3-1: Motor Connections

Pittman N2311 Motor Terminals		MC-IO	MV-PWR-LV
Phase U	- Beige	—	J3 - 1
Phase V	- Red	—	J3 - 2
Phase W	- Orange	—	J3 - 3
Hall sensor 1	- Gray	J5–13	—
Hall sensor 2	- Blue	J5–14	—
Hall sensor 3	- White	J5–7	—
Hall sensor $5V_{DC}$	- Purple	J5–6	—
Hall sensor GND	- Black	J5–5	—

Motor terminal connections are shown in Figures 3-2 and 3-3.

Figure 3-2: Motor Phase Connections

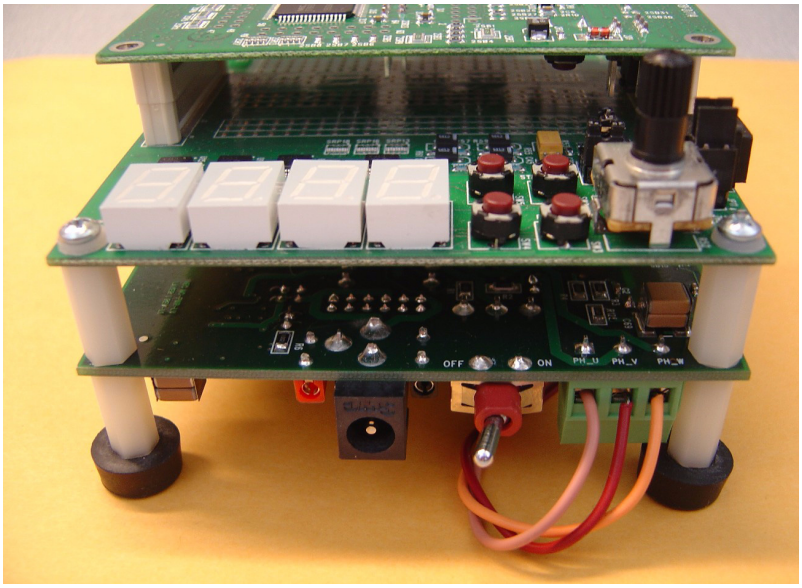
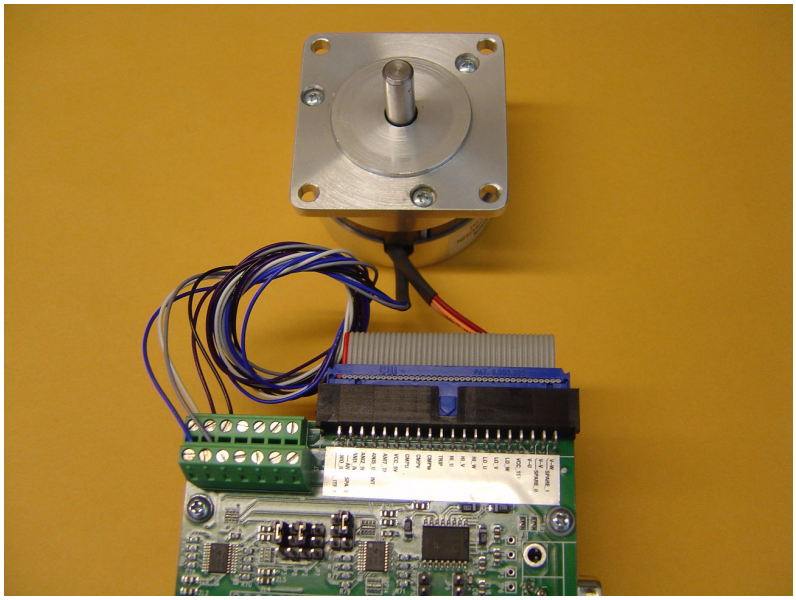


Figure 3-3: Hall Sensor Connections

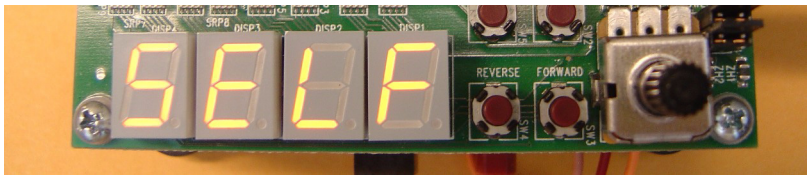


The software to run the motor is programmed into the microcontroller's flash memory. After the motor is connected, the program is ready to run the motor as soon as the 15 V_{DC} power supply is plugged into J6 of the MC-IO board.

When the kit is powered up or reset, the LED displays "**SELF**", indicating that the kit is in standalone mode and you can use the push buttons and potentiometer on the MC-IO board to control the motor.

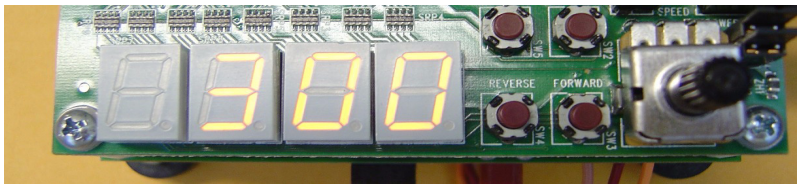
To control the motor from a GUI on your PC, connect a serial cable to the J9 RS-232 port on the MC-IO board and rebuild the code with the GUI macro option as described later in this manual.

Figure 3-4: Standalone Operation



Three seconds after power up, the LED displays the current set speed.

Figure 3-5: Speed Display



Chapter 4 Standalone Operation

After power up in standalone mode, the motor can be operated as follows:

<1> Press the **START/STOP** button to run the motor.

<2> Turn the potentiometer clockwise to accelerate or counterclockwise to decelerate.

<3> Wait for the LED to display the actual motor speed calculated from the Hall sensor interrupts.

<4> Press the **FORWARD** or **REVERSE** button to change the rotation direction.

<5> Press the **MODE** button to display the set speed.

<6> Press **START/STOP** to stop the motor.

Note: If the potentiometer position is set to higher speeds, and the motor rotation is suddenly reversed, an error condition may occur due to a time-out or over-current detection and the motor will stop operating. To reboot, press the **RESET** switch on the MC-IO board, adjust the potentiometer to a lower speed and restart.

Chapter 5 Drive and Motor Protection

The starter kit and the motor are protected against unexpected events such as overload, motor stall and malfunction of the Hall sensors. If such faults are detected, the motor stops rotating and the fault condition is displayed on the seven-segment LED. For details on the protection functions implemented in hardware, consult the user's manual for MC-PWR-LV low-voltage power module. The sample code software also has built-in fault detection algorithms as an extra measure of protection. Consult the software manual for details.

In standalone (SELF) mode, the LED displays the following fault conditions:

- Motor over-current: "O – C – "
- Motor stall fault: "– – – –"
- Hall sensor fault: "H A L L"

In PC (GUI) mode, the LED displays "PC" all the time and the GUI will displays all fault conditions. Refer to section Chapter 10 "GUI Operation" on page 28 for more information.

Chapter 6 Software Setup

The software CD-ROM bundled with the kit contains PDF versions of this document, the user manuals and electrical schematics for all hardware module components, and the entire sample project program for the NEC Electronics 78K0 firmware-based development tools environment. The software sample code is supplied in source format and can be modified as needed.

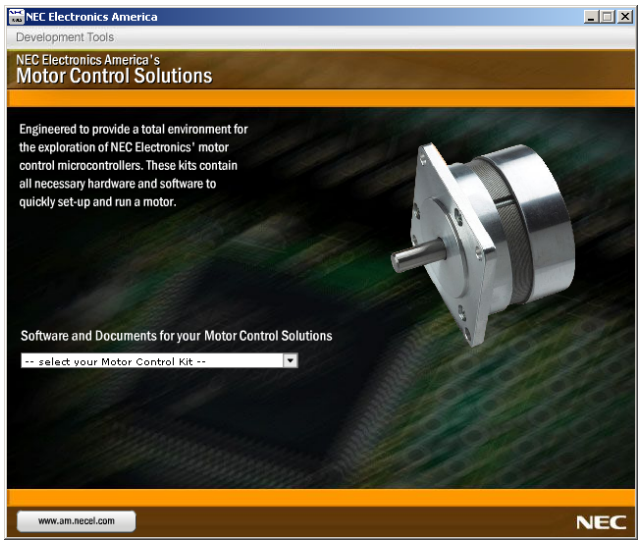
The following sections describe NEC Electronics America's development tools environment, how to install it on your computer, and how to rebuild and download executable code to the microcontroller's flash memory.

Before proceeding with the tools installation, however, refer to all of the documentation on the CD-ROM for detailed information about the starter kit and the sample software.

Chapter 7 Software Installation

<1> Insert the CD-ROM supplied with your MC-LVKIT-714 starter kit.
<2> The CD-ROM should initialize automatically. If it doesn't, click **Start** → **Run**. Browse to your CD-ROM drive and select **Motol_Control.exe**.
<3> Select **MC-LVKIT-714** from the drop down list.

Figure 7-1: Motor Control Software and Documents Installation GUI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-- select your Motor Control Kit --
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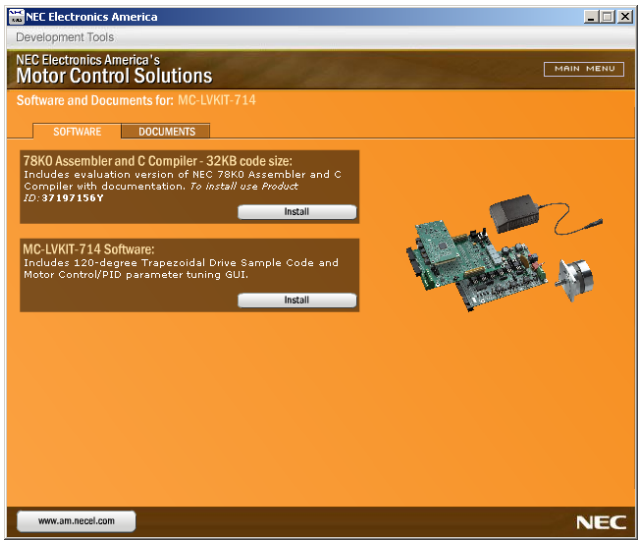
<4> Install all of the software in the following recommended sequence:

- NEC Electronics C compiler and assembler software
- MC-LVKIT-714 software

Figure 7-2: Software Installation Window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SOFTWARE
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Includes evaluation version of NEC 78K0 Assembler and C Compiler with documentation. To install use Product ID: 37197156Y
Install
MC-LVKIT-714 Software:
Includes 120-degree Trapezoidal Drive Sample Code and Motor Control/PID parameter tuning GUI.
Install
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Chapter 8 Using the NEC Electronics C Compiler and Source Code Debugger

To set up the MC-LVKIT-714 starter kit for debugging, follow the steps below.

<1> Disconnect the M-78F0714 micro board by separating it from the MC-IO board.
<2> Remove jumpers JP5 2-5, JP5 3-6 and 2JP7 1-2 and reconnect M-78F0714 to MC-IO board.

Figure 8-1: Jumpers for Standalone Operation

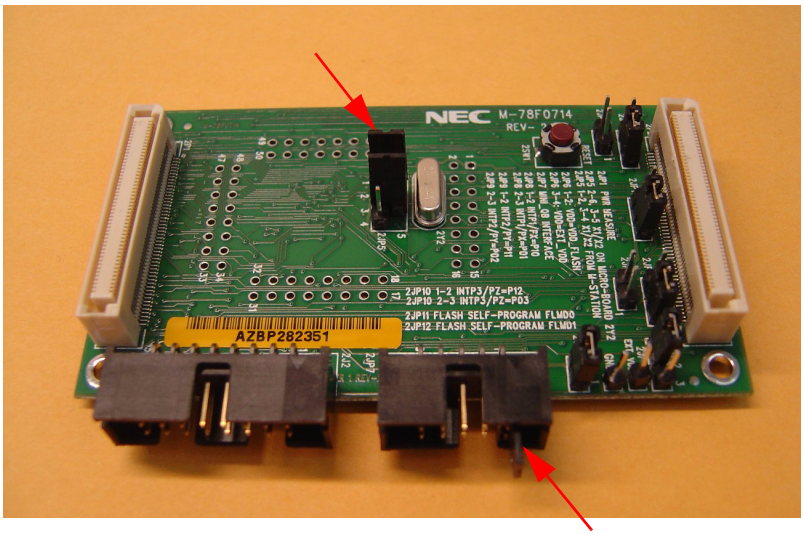
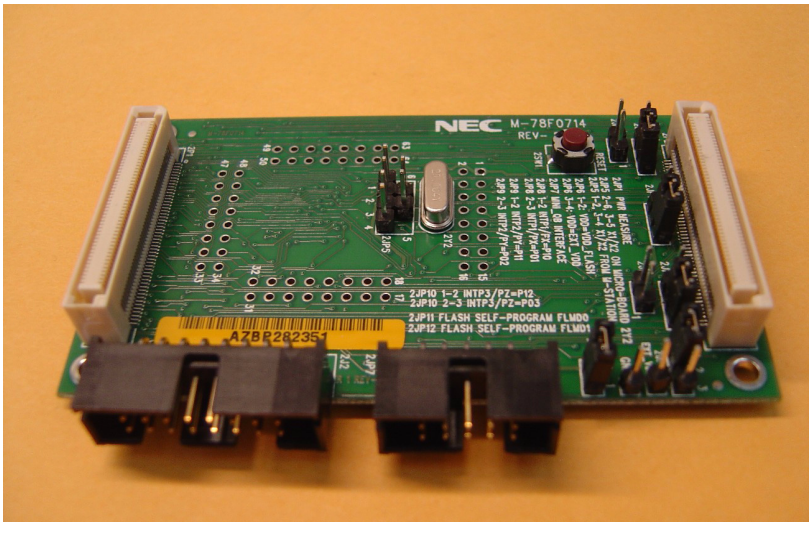
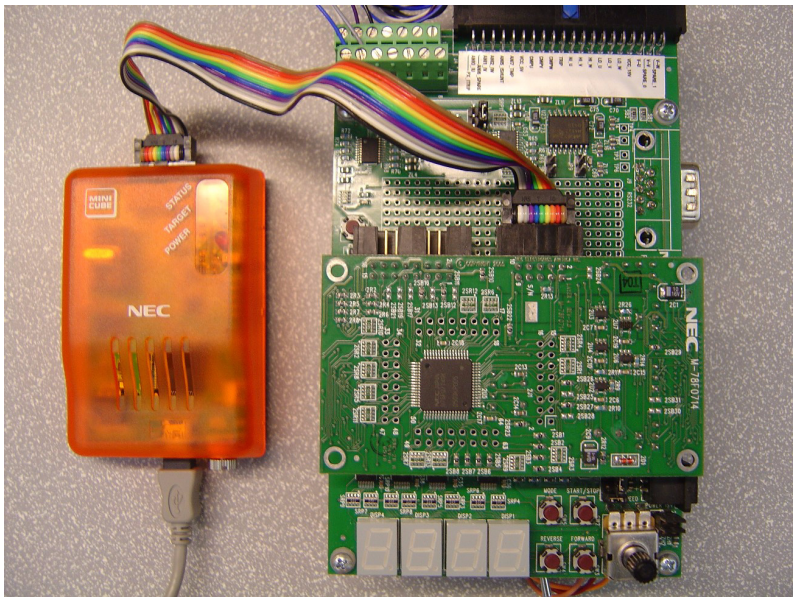


Figure 8-2: Debugging Setup



<3> Attach the on-chip debugging emulator's target connector to 2JP7 on the M-78F0714 and the USB cable to your computer as shown bellow.

Figure 8-3: Debugging Environment Shown with QB-78K0MINI On-Chip Debugger



Note: The on-chip debugger has a 5 MHz internal clock source by default.

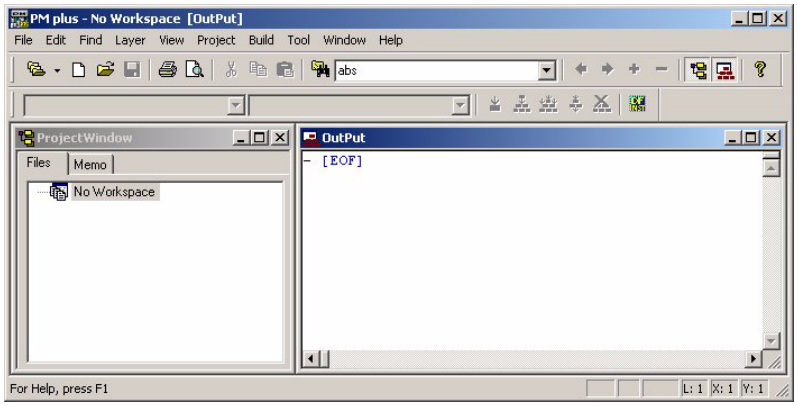
The MC-78F0714 must be operated at 20 MHz. Use the external 20 MHz oscillator supplied with the kit. Consult the on-chip debugger user's manual for information about how to attach the external oscillator.

The sample program "BLDC-Hall-714-LV 120-degree Trapezoidal Drive" is installed in step (b) of the "Install Software" section in \Motor_Control\BLDC_Hall_714 folder. The sample code includes a work-space and project files used with Project Manager Plus, which is NEC Electronics' integrated develop-ment environment software.

To recompile and debug the sample program follow the steps below:

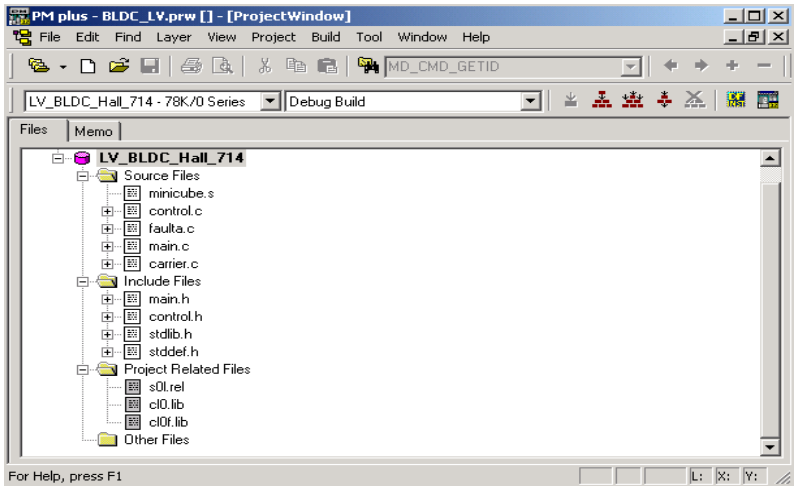
<1> Run **PM Plus** program installed by the NEC Electronics assembler software.
<2> Launch **PM Plus** from **Start** →**Programs** →**NEC Tools32**.
<3> **PM Plus** will display its main window as shown below.

Figure 8-4: PM Plus Workspace



<4> Click **File** and select **Open Workspace**.
<5> Browse to C:\NECTools32\ \Motor_Control\BLDC_Hall_714 and select BLDC_LV.prw PM Plus workspace file.
<6> The newly loaded workspace file will contain one project called LV_BLDC_Hall-714.prj as shown below.

Figure 8-5: PM Plus Window

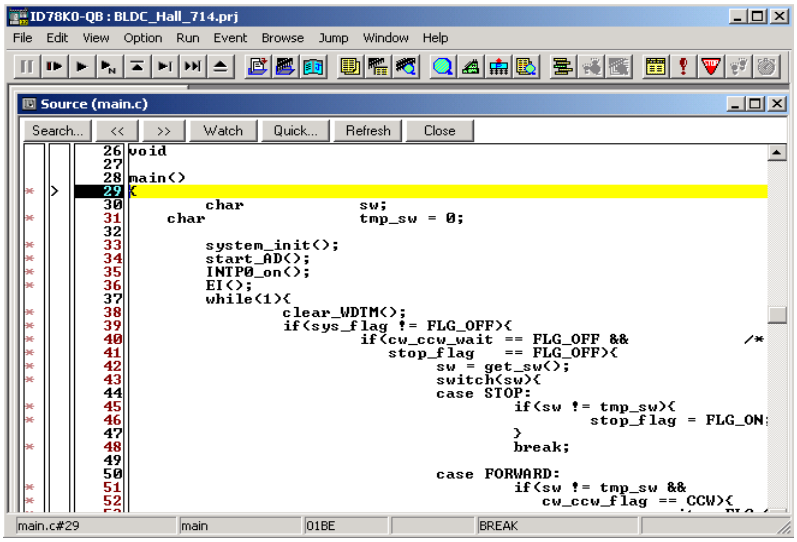


<7> To recompile the code, click **Build** and select **Rebuild**.
<8> At this point, you may change the code and recompile as needed.
<9> After building the code successfully, you may download and run or debug the code using an on-chip debugging emulator.

Chapter 9 Download and Debug the Code

<1> To debug the code, select **Debug** from Build menu or click the **Debug** button on the tool bar. By default the code automatically will be downloaded to the microcontroller's flash memory through the on-chip debugging emulator and the source code displayed in the **Debugger** window as shown below.

Figure 9-1: Source Code in Debugging Window



<2> Use the **RUN** command to execute code in debugging mode. At this point, the motor can be controlled from the user interface in standalone mode or GUI mode.

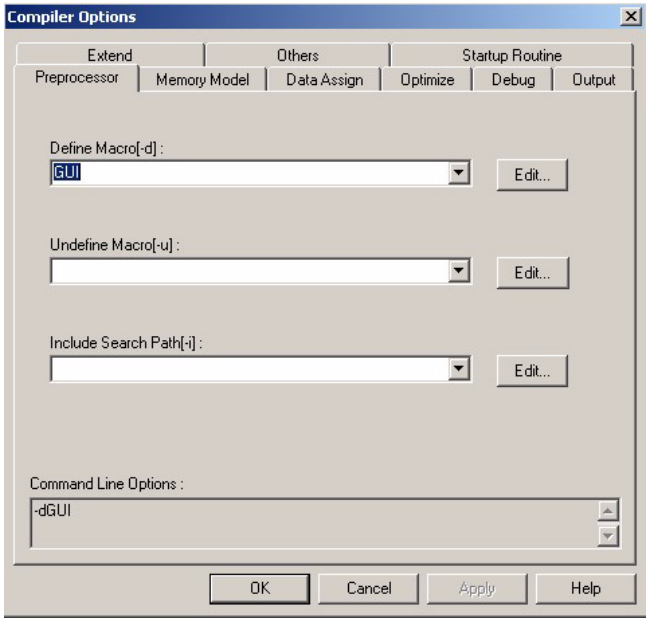
<3> Stop execution using the **STOP** button.

<4> For details on how to use the debugger, consult the ID78K0-QB User's Manual.

Chapter 10 GUI Operation

To operate the motor from the PC GUI, the code has to be rebuilt with “GUI” option. Select Compiler Options from PM+ Tool menu and type “GUI” in Preprocessor →Define Macro entry.

Figure 10-1: Compiler Options for PC GUI Operation



Rebuild and download the code to the microcontroller flash. At this point the motor can be controlled from the GUI only.

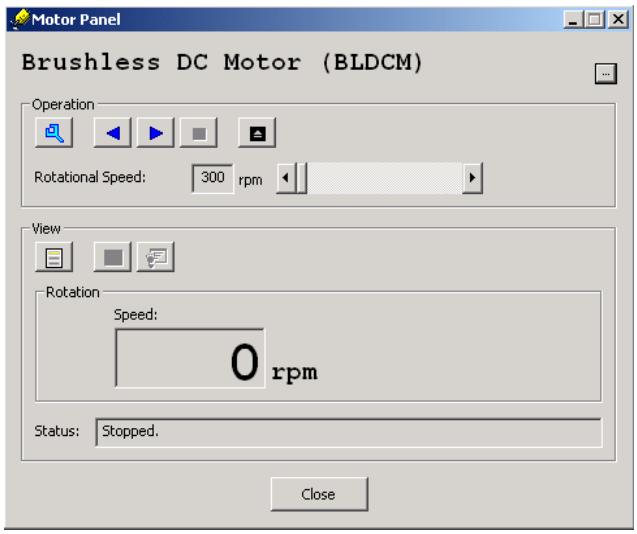
Connect the PC serial port to the starter kit J9 DB-9 RS232 connector with the serial cable supplied and launch the communication program Motor Panel, click Start →Programs →NEC Tools32 →Motor Panel GUI.

<1> Select the appropriate COM port your PC and click OK.

Figure 10-2: PC COM Port Selection

The GUI will launch if the connection is established:

Figure 10-3: BLDCM GUI

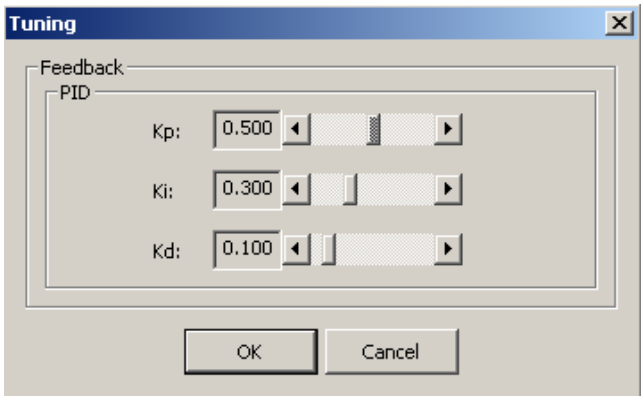


<2> To operate the motor, use the controls in the GUI.
<3> To change the PID parameters click on the tuning key symbol

Figure 10-4: Launching PID Parameter Window

The tuning window will allow the changing of P, I or D constants:

Figure 10-5: PID Parameter Window



The new parameter values will be updated in the internal RAM when the motor is restarted again. To make the changes permanent, the user has to update #define values in on KP_DEF, KI_DEF and KD_DEF in control.h header file and rebuild the code.

[MEMO]